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Naval Postgraduate School
Monterey, California 93943-5138

SUMMARY OF RESEARCH 1995

Department of Aeronautics and Astronautics

Daniel J. Collins
Chairman

Oscar Biblarz
Associate Chair for Research

Prepared for: Naval Postgraduate School
Monterey, CA 93943-5000

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13. ABSTRACT (Maximum 200 words.)

This report contains 40 summaries of research projects in the Department of Aeronautics and Astronautics which were carried out under funding of the Naval Postgraduate School Research Program. A list of recent publications is also included which consists of conference presentations and publications, books, contributions to books, published journal papers, and technical reports.

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral M.J. Evans
Superintendent

R. Elster
Provost

This report was prepared for the Naval Postgraduate School, Monterey, CA.

The report was prepared by:

Frances M. Smith
Research Admin Assistant
Research Office

Reviewed by:

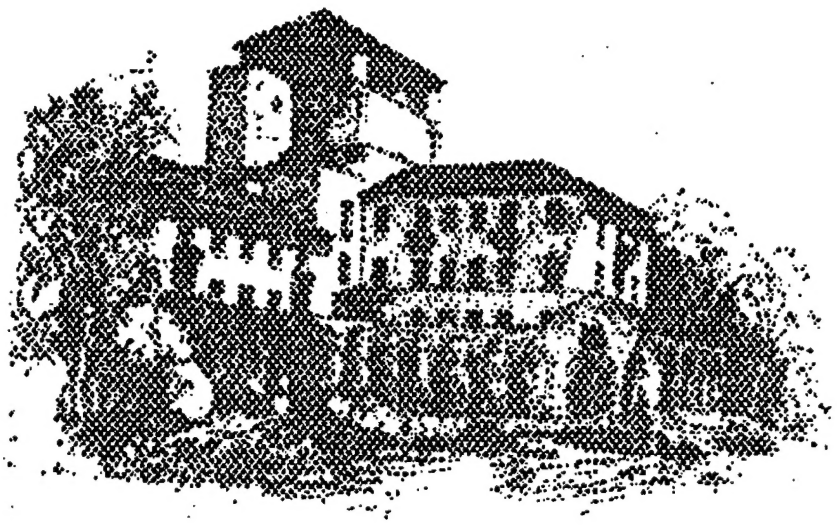
Danielle A. Kuska
Programs Supervisor
Research Office

Released by:

David W. Netzer
Associate Provost and Dean of Research

THE NAVAL POSTGRADUATE SCHOOL MISSION

The mission of the Naval Postgraduate School is to provide advanced professional studies at the graduate level for military officers and defense officials from all services and other nations. The School's focus is to increase the combat effectiveness of the armed forces of the United States by providing quality education which supports the unique needs of the defense establishment.



Introduction

Research is an integral part of graduate education. At the Naval Postgraduate School (NPS), the goals of research are to:

- Provide a meaningful, high quality, capstone learning experience for our students.
- Keep faculty on the leading edge of advances in defense-related science, technology, managment and policy to ensure that the latest information is incorporated into NPS courses and curricula.
- Apply faculty and student knowledge to enhance Navy/DoD operational effectiveness.

Pursuit of these goals increases the technical and managerial capability of the officer corps to keep pace with an increasingly complex defense posture in today's world.

The overall research program at NPS has two funded components:

- The Direct Funded Research (DFR) Program provides internal funding from the School's operating budget to stimulate innovative research ideas of benefit to the DoN and may be used for cost-sharing with reimbursable research efforts. This funding ensures, in particular, that all Navy-sponsored NPS curricula are equitably supported, that new faculty are provided an opportunity to establish a research program of importance to DoN/DoD and other national security interests, and that faculty and students from across the campus are encouraged to interact with one another.
- The Reimbursable Research (RR) Program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policy makers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. This ensures that NPS research remains highly regarded by academic peers and government officials and fosters a closer relationship between NPS and other outside organizations.

The two research programs are complementary and ensure that the overall research program is flexible, responsive, balanced and supportive of the unique needs of the military.

All research projects, both reimbursable and direct funded, support the School's research mission:

- To develop an overall research investment strategy that ensures a high quality, creative learning experience for NPS graduate students.
- To encourage faculty and student pursuit of new discoveries and applications which enhance the long term effectiveness of the armed forces.
- To stimulate interactions between NPS faculty and a wide variety of potential research sponsors (Government, Universities, Private Industry).
- To publicize (both internally and externally) significant achievements of the NPS research program and market NPS research capabilities.
- To foster synergy and force multiplication with Navy/DoD commands and laboratories to increase the potential for successful research and development programs

The Department of Aeronautics and Astronautics provides advanced education in Aeronautics Engineering, Astronautical Engineering and Avionics Engineering. The Department is fully staffed with full-time faculty representing the different technical specialties. Additional support is provided in the Departments of Mathematics, Physics, Mechanical Engineering and Electrical and Computer Engineering. In order to develop and maintain their expertise, as well as to provide support for student thesis research, faculty members perform research in their disciplines for all military services and NASA.

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Collins, Daniel J.
Professor & Chairman
AA/Co
656-2311 (phone)
656-2313 (fax)
collins@aa.nps.navy.mil

Biblarz, Oscar
Professor & Associate Chair for Research
AA/Bi
656-3096
obiblarz@nps.navy. mil

Agrawal, Brij N.
Professor
AA/Ag
656-3338
agrawal@aa.nps.navy.mil

Ball, Robert E.
Distinguished Professor
AA/Bp
656-2885
ball@aa.nps.navy.mil

Brawley, Stephen C., LT
Lecturer
AA/Br
656-2944
sbrawley@aa.nps.navy.mil

Chandrasekhara, Muguru S.
Research Professor
AA/Ch
656-3103
chandra@aa.nps.navy.mil

Hebbar, Sheshagiri
Visiting Associate Professor
AA/Hb
656-1103
hebbar@aa.nps.navy.mil

Hobson, Garth V.
Associate Professor
AA/Hg
656-2888
garth@aa.nps.navy.mil

Howard, Richard M.
Associate Professor
AA/Ho
656-2870
howard@aa.nps.navy.mil

Kaminer, Isaac I.
Assistant Professor
AA/Ka
656-5040
kaminer@aa.nps.navy.mil

King, Robert L.
Lieutenant
AA/Ki
656-2944
rlking@aa.nps.navy.mil

Leonard, Barry
Visiting Assistant Professor
AA/Lb
656-2926

Lindsey, Gerald H.
Professor
AA/Li
656-2808
lindsey@aa.nps.navy.mil

Netzer, David W.
Distinguished Professor
AA/Nt
656-2980
netzer@aa.nps.navy.mil

Newberry, Conrad
Professor
AA/Ne
656-2892
newberry@aa.nps.navy.mil

Platzer, Max F.
Distinguished Professor
AA/Pl
656-2058
platzer@aa.nps.navy.mil

Ross, I. Michael
Assistant Professor
AA/Ro
656-2074
ross@aa.nps.navy.mil

Schmidt, Louis
Professor Emeritus
AA/Sc
656-2804

Scrivener, Sandra
Assistant Professor
AA/Ss
656-2936
sandi@aa.nps.navy.mil

Shreeve, Raymond P.
Professor
AA/Sf
656-2593
shreeve@aa.nps.navy.mil

Tuncer, Ismail
Research Assistant Professor
AA/Tu
656-2854
et@nps.navy.mil

Wood, E. Robert
Professor
AA/Wd
656-2897
rwood@wposmtp.nps.navy.mil

Wu, Edward
Professor
AA/Wu
656-3459

AERONAUTICS AND ASTRONAUTICS

Research in the Department of Aeronautics and Astronautics is focused on topics of critical importance to military users. Typically, research activity resides in the Department's five technical groups, namely, Aerodynamics, Structures, Propulsion, Flight Mechanics and Controls, and System Design. Both aircraft and spacecraft are involved. Present Departmental endeavors are described below.

Aerodynamics

ENHANCED AIRCRAFT MANEUVERABILITY STUDIES

In support of the Naval Air Warfare Center, Aircraft Division, Professors Platzer and Hebbar performed water tunnel tests to investigate the effect of Reynolds number on the vortical flow over double-delta wings at high angles of attack.

HIGH-ANGLE-OF-ATTACK MISSILE AERODYNAMICS AND HYPERSONICS

In support of the Naval Air Warfare Center, Weapons Division, Professors Platzer and Tuncer are developing solutions for the flow over missile configurations in steady and unsteady subsonic high angle of attack flight using Navier-Stokes and panel code modelling.

NASA/USRA grant funding was available to Professor Newberry to improve the aeronautical design program at the NPS and to encourage the configuration development of tactical waverider aircraft. This funding has provided the aeronautical design laboratory with a variety of hardware (SGI workstation, PC, color printer) and software (design reference books, design synthesis codes, miscellaneous supplies). Design team reports and conference papers have been generated to document research activity supporting the configuration development of carrier capable tactical waverider aircraft of interest to the DoN, ARPA, DoD and NASA. NASA Ames Research Center has also provided reimbursable funding for this waverider research.

BOUNDARY LAYER CONTROL

Professor Platzer is performing systematic water tunnel tests, supported by the Office of Naval Research, to explore the effectiveness of a new boundary layer and flow separation control method for drag reduction and lift enhancement.

TOPICS RELATED TO ADVANCED ROTORCRAFT

A program led by Professor Wood has five areas. First, research continues to be conducted on the unsteady aerodynamics related to higher harmonic control (HHC). HHC is an active control system concept which promises reduced helicopter vibrations, lower rotor noise levels and improved helicopter performance. Recent NPS research based on the results from the 1984 NASA/Army/McDonnell Douglas OH-6A HHC flight test program shows that a reduction in rotor power results due to the unsteady wake shed by the rotor with HHC turned on. In this area, NPS is teamed with SatCon Technology and McDonnell Douglas Helicopters to conduct rotor whirl tests this year at the MDHC facility. Rotor power and hover will be measured with HHC "off" and HHC "on" to quantify the amount of power reduction to be expected with an HHC system. The OH-6A rotor hub and blades for these tests will be provided by NPS. Second, research is being conducted on the no tail rotor (NOTAR) concept which uses circulation control aerodynamics (Coanda) effect to counter the torque from the helicopter's main rotor in place of a conventional tail rotor. This research is being carried out using the NPS "Hummingbird", a 1/4-scale remotely piloted helicopter with a NOTAR tailboom designed and built at NPS. Third, real-time flight simulation is being carried out for the Navy's SH-60B helicopter under sponsorship from NAWC, Patuxent River, Md. The simulation makes use of FLIGHTLAB, a unique computer software program developed by Advanced Rotorcraft Technology that permits detailed modelling of aircraft to a level never before considered possible including many higher order and non-linear effects. Fourth, NPS received two full scale OH-6A flightworthy helicopters from the Army National Guard in October. One of the helicopters will be removed from flying status and serve as a baseline model for helicopter structural dynamics research. In this area, Profs. Wood (AA), Gordis (ME), and Danielson (MA) are being funded by the Army RAH-66 Comanche office to provide a backup NASTRAN dynamic model of the Comanche to be used for exploring potential vibration problem areas, should they

surface from the current RAH-66 flight test program being conducted by Sikorsky and Boeing at WestPalm Beach, Florida. The laboratory OH-6A helicopter provides a baseline model for training students in this program. That, is NPS students get experience in helicopter vibration testing by conducting vibration tests of the OH-6A here. Test results are correlated against a finite element model of the OH-6A which has been provided the school by MDHC. Following this work, the students have the background to apply their training to analysis of the Army's new RAH-66 Comanche helicopter, which first flew on January 4, 1996, and which will be involved in flight tests to expand its flight envelope throughout the rest of this year. The second OH-6A helicopter will be maintained on flight status and used for research on helicopter noise and vibrations, and instruction in helicopter flight testing.

ENHANCED HELICOPTER MANEUVERABILITY

Professors Chandrasekhara, Platzer and Tuncer are performing experimental and computational studies on the dynamic stall characteristics of helicopter blades. Experiments are being carried out to develop practical adaptive-geometry techniques for controlling flow separation. Also, Navier-Stokes methods are being developed to predict the formation of separation bubbles on the onset of dynamic stall. These studies are partially supported by the Army Research office.

Structures

FAILURE AND LIFE PREDICTION FOR ADVANCED COMPOSITE AND AGING ALUMINUM VEHICLE STRUCTURES

Increased use of composites structures in all weapons platforms requires that there be developed reliable predictive methods for failure and probable structural life. Professor Wu has undertaken this fundamental problem using an analytical approach which separates fiber, matrix and interface mechanisms, and uses carefully controlled experiments to establish necessary statistical strength and life data. A unique new laboratory for composites has been established at NPS and the first successful research results have now been reported.

STRUCTURAL & DYNAMIC ANALYSIS AND DESIGN OF SPACECRAFT

Professor Scrivener and two NPS students helped conduct a 2 axis shock and vibration test on the Ya-21 TOPAZ II unit at Sandia National Labs in September 1995. The students, performed a finite element analysis on a model of the TOPAZ II structure, and correlated the experimentally determined frequencies with those predicted by the model. The match was very close, and it was concluded that the test had excited all the relevant modes of the structure, and that the model was a good indicator of the actual behavior of the unit. In addition to advising a thesis in 1995 on the analysis and design of the adaptor fitting for PANSAT, Professor Scrivener also advised a thesis on the structural analysis and design of the EPS housing and circuit boards for PANSAT. The design is currently being implemented by the PANSAT engineers. This thesis work explored the static and dynamic behavior of the EPS housing and circuit boards, and determined the physical properties of the printed circuit board material through experimental methods. Also performed was a finite element analysis of the components and the assembly to compare the behavior of a more complex model to that of the simplified one used for hand calculations.

Propulsion

ADVANCED AIRCRAFT ENGINE AND MISSILE PROPULSION STUDIES

Currently in its second phase, the goals of the third phase of the (tri-service, government/industry) Integrated High Performance Turbine Engine Technology (IHPTET) Program can only be reached by achieving very significant performance and weight advances in each of the engine components. Advancing fan and compressor and turbine aerodynamics (to allow higher-blade loading) is the focus of the work of Professors Shreeve and Hobson at the Turbopropulsion Laboratory. The general approach is to use the laboratory's exceptional experimental facilities to

validate CFD codes being developed for use in advanced design. The off-design and stalling behavior of controlled-diffusion compressor blading is being measured in a very large-scale subsonic cascade wind tunnel. The alleviation of shock boundary-interaction losses is being studied in a transonic blow-down wind tunnel model simulation of the flow through fan passages. A new stage designed by NASA using 3D CFD codes is being prepared for evaluation in the transonic compressor rig. Pressure sensitive paint has been developed as a diagnostic for the rotor flow. The details of flow in the tip region of high speed turbines is to be studied using, as a tool, the Space-Shuttle Main-Engine fuel-pump turbine and an annular cascade. Two- and three-dimensional traversing Laser-Doppler Velocimeter (LDV) systems have been developed for velocity field mapping. The development of successful diagnostic techniques to resolve small- scale, three-dimensional effects near to walls is necessary to achieve the goals of this and the IHPTET program.

Professor Netzer's work at the Combustion Laboratory is directed at several missile and gas turbine areas; (1) development of a small, low cost, long-range, combined-cycle motor for lethal UAV or helicopter, (2) fuel additive effects on plume IR signature of liquid rocket motors and gas turbine engines, (3) effects of particulates on supersonic shearlayer mixing and plume IR signature (ONR), (4) combustion behavior of high energy liquid and solid fuels, (5) optimization of inlets and fuel distribution for liquid-fuel ramjets (NAWCWD) and (6) development of liquid fuel injection for a pulse-detonation engine. Professors Biblarz and Netzer have been developing an instrument for the on-line determination of soot concentration within the test cell environment (NAWCAD).

Flight Mechanics and Controls

UNMANNED AIR VEHICLE (UAV) TECHNOLOGY

In support of the DoD's role in the development of UAVs, Professor Howard has developed a UAV flight research laboratory at NPS using several flight platforms for the development and testing of flight controls and flight mechanics applications. The broad goal is to develop innovative technologies and flight-control techniques applicable to UAVs, including HAE (high altitude endurance), Tactical, and Vertical Takeoff and Landing (VTOL) configurations. The design, construction and testing of a full-scale VTOL UAV has been initiated. The current focus, jointly with Professor Kaminer, is on the development of autonomous guidance, navigation and control of a conventional air vehicle to validate the technology prior to extension to the VTOL platform. Flight testing of the avionics, airborne sensors, and datalinks is underway. Professors Howard, Kaminer and Netzer are also investigating a lethal UAV concept for the detection and destruction of ballistic missiles prior to launch.

IMPROVING AIR VEHICLE CONTROLS & MILITARY APPLICATIONS OF NEURAL NETWORKS

In his work, Professor Kaminer addresses the problem of integrated design of guidance and control systems for autonomous vehicles (AVs). In fact, we have developed a new methodology for integrated design of guidance and control for autonomous vehicles. The methodology proposed leads to an efficient procedure for the design of controllers for AVs to accurately track reference trajectories defined in an inertial reference frame. This methodology was applied to the design of a tracking controller for the Unmanned Air Vehicle Bluebird at the NPS UAV Lab and to the Autonomous Underwater Vehicle Marius at the Instituto Superior Tecnico of Lisbon, Portugal. Furthermore, we are working on the development of closed loop criteria for tail sizing criteria of commercial supersonic aircraft using newly developed integrated plant/controller design methodology. The key idea is to rewrite the tail sizing and feedback requirements as Linear Matrix Inequalities. In particular, the effects of feedback specifications, such as MIL STD 1797 Level I and II flying qualities requirements, and of actuator amplitude and rate constraints on the maximum allowable cg travel for a given set of tail sizes were considered. A static state feedback controller was designed as a part of the tail sizing process.

Following work on the X29 controller, Professor Collins has extended his work on neural networks to two important Navy problems. In the first, neural networks are being developed to identify transient sonar signals. In the second, neural network technology is being applied to ionospheric modeling and to PMA operator training.

ATTITUDE CONTROL, MANEUVER & SMART STRUCTURES

In this program, under the supervision of Professor Agrawal and in support of DoD, the emphasis is on the development of improved control techniques for attitude control of flexible spacecraft using thrusters and vibration control and antenna shape control using smart structures technology. Pulse-Width Pulse-Frequency (PWPF) modulator thruster control parameters were analyzed to minimize interaction with flexible spacecraft structures. Analytical model to optimize the locations of piezoceramic actuators to minimize beam shape error was developed. A finite element model for laminated composite plate with piezoceramic actuators using higher order shear deformation theory was developed.

ASTRODYNAMICS

Astrodynamics is the study of the motion of natural and artificial bodies in space. In support of DoD's role in the prediction and control of spacecraft motion, Professor Ross conducts research in the area of trajectory maneuver and optimization, singular control and mission design. A "bang-bang" maneuver called aerobang was developed by Professor Ross for the purpose of minimizing propellant use for orbital plane-change maneuvers. He and his students have mapped the efficacy regions for the maneuver and are currently working on optimizing the trajectory. Under Professor Ross' guidance, a team of students designed single- and dual-burn maneuvers for low-Earth-orbit maintenance. In support of the Air Force Space Command, another team of students, guided by Professor Ross and Hall (at AFIT), are currently working on mission design for near-Earth-orbit interception. Finally, Prof. Ross has developed a refined Energy-Sink Theory that has lead to the resolution of a decade-old debate on the stability of Dual-Spin spacecraft.

System Design

MULTI-DISCIPLINARY DESIGN OPTIMIZATION

Under a Cooperative Research & Development Agreement (CRADA) with the McDonnell-Douglas Corporation, Professor Platzer is contributing to the development of advanced multi-disciplinary analysis and design methods for subsonic transport aircraft.

In Spacecraft Design, Under Professor's Agrawal's supervision, two design projects were completed: Tomography Satellite System and EHF Communications Satellite. The mission of the Tomography Satellite System was to provide a "near real time" map of the ionosphere. Two different radio waves are sent by the satellite simultaneously and the relative delay of the signals determines electron content along the path of the signal. EHF communication satellite in a highly elliptical orbit provided EHF communications for the mobile tactical users above 650 N latitude, the area not covered by geosynchronous satellites.

JSOW CATM Project

Professor Lindsey is leading a multi-disciplinary project which involves the preliminary conceptual development of a Captive Air Training Missile (CATM) to be used in fleet operations for training pilots in the use of the Joint Stand-Off Weapon (JSOW) missile. A Concept of Operations for the CATM has been written, from which functional requirements are to be drawn up. Exploratory work on the conceptual design is to be done in (1) airframe structural design and weight estimation; (2) aerodynamic analyses for flight loads and contour shaping for minimum drag; (3) flight simulation of the JSOW by the CATM carrier aircraft; and (4) exploration of communications between the CATM on the carrier aircraft and the data link pod on the control aircraft.

Joint reimbursable funding has been obtained by Professor Newberry to determine the attributes and parameters of aircrew-centered system design. This funding has been channeled through NAWC/China Lake for the purpose of defining the system design procedures and methodology for aeronautical systems which maximize the effectiveness of aircrew performance during manned missions.

AIRCRAFT COMBAT SURVIVABILITY AND LETHALITY ASSESSMENT

Professor Ball originated the study of aircraft combat survivability at NPS in 1974 and has provided technical support for the Naval Air Systems Command (NAVAIR) and the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS); (1) by writing a textbook in aircraft combat survivability ("The Fundamentals of Aircraft Combat Survivability and Design", published by the American Institute of Aeronautics and Astronautics (AIAA) in 1985), (2) by conducting over 15 short and shorter courses in survivability since 1978, (3) by developing the NPS/NAVAIR Survivability and Lethality Assessment Center (SLAC), and (4) by conducting a variety of studies on the survivability of US aircraft and the lethality of US air defense systems. In FY 1995, the majority of efforts were devoted to; (1) the continued development of the second edition of the AIAA survivability textbook, (3) the continued development of the SLAC, primarily through the addition of MOSAIC, a computer program that models the flyout of an infrared missile toward an aircraft ejecting flares, and (4) three MS degree studies on the survivability of aircraft. Two of the studies used MOSAIC to study the effects of flare dispensing on the survivability of the P-3 Orion and F-14A Tomcat aircraft against infrared missiles. The third study examined the effects of digital avionics systems on the survivability of modern tactical aircraft.

Aeronautical Laboratories

Excellent research facilities are available to support the department's research programs.

The Subsonic Aerodynamics Laboratory consists of three wind tunnels and a water tunnel. The 28-inch by 45-inch low-speed tunnel, with speeds to 150 fps, is commonly used with a six-component sting balance for three-dimensional model testing. The 3.5-foot by 5-foot low-speed tunnel runs at speeds of 200 fps and accommodates larger models. The 5-foot by 5-foot flow visualization tunnel is used for environmental testing. The 1-foot by 1-foot water tunnel is also used for flow visualization of fighter missile models with dye injection.

The Combustion Laboratory consists of an instrumented control room, a propellant evaluation laboratory, a high-pressure air facility, and three test cells. These test cells are equipped for investigating solid and liquid rocket propellant rocket motors, liquid- and solid-fuel ramjets, and gas-turbine combustion. Diagnostic methods include ensemble and phase-Doppler particle analyzers, spectrographs, thermal imaging cameras, spectroradiometers, plused laser sheet and schlieren, holography, and various sampling probes. Several windowed combustion bombs are also used to measure the ignition and combustion characteristics of high-energy liquid and solid fuels.

The advanced facilities of the Turbopropulsion Laboratory are in two buildings. The first provides low-speed tests with rectilinear and radial cascades of large dimensions and an axial-flow, three-stage compressor. The second building is used for high-speed testing of research turbomachines. Digital data-acquisition and control equipment for steady-state and real-time flow measurements up to 100 kHz are available with computer-controlled data reduction and presentation on line. Laser diagnostics include one two-component and one three-component fiber-optic laser-Doppler anemometer system with 3-axis programmable traversing and automatic data processing and plotting.

The Mechanics and Materials for Composites Laboratory is equipped with fabrication and testing facilities for characterizing the mechanical behavior of fiber-reinforced composites. Fabrication facilities include an oven and press with provisions for computer control of temperature and pressure profiles for fabrication of laminates and strands. Testing facilities include five mechanically driven universal testing machines for general use; and unique, extensive facilities for life testing of fiber filaments and composites. These facilities are supported by a wide array of modern data-acquisition instruments including computer-controlled data loggers, digital voltmeters, acoustic-emission analyzer, and laser-diffraction instruments. Personal computers provide ample capacity for analytical interpretation of data and model formulation.

The Controls Laboratory currently consists of five experimental setups with associated computers and graphic interfaces. Each experiment is a physical device, which includes input limitations, hysteresis effects, and dead space. A computer interface and software program permit the design of a wide range of controllers for the experiments.

The Flight Mechanics Laboratory consists of a general-aviation flight simulator used for teaching flight test engineering and the Unmanned Air Vehicle (UAV) Flight Research Laboratory. In the UAV Lab, research with radio-controlled aircraft is conducted in the areas of aerodynamics, performance, stability and control, and avionics design. The Flight Mechanics Lab is supported by the department's wind tunnels.

The Avionics Laboratory designs, analyzes, and integrates the avionics on unmanned air vehicles. The Lab's five workstations and three PCS are equipped with the hardware and software necessary for developing navigation, guidance, and control, as well as the complete process of testing these algorithms; first on the nonlinear simulation, then on the hardware-in-the-loop simulation, and finally in the flight test. The Lab is also getting involved in the design and real-time three-dimensional testing of cockpit display concepts.

The NPS/NAVAIR Survivability and Lethality Assessment Center, established in 1993, contains computer programs that can be used to assess the survivability of US aircraft and missiles, as well as the lethality of US anti-air

weapons against enemy aircraft and missiles. Available programs include the Air-to-Air System Performance Model, the Advanced Low Altitude Radar Model, the Variable Airspeed Flight Path Generator, ACES/Phoenix, and the Extended Air Defense Simulation. The Center has both secure and unclassified facilities.

The Design Laboratory is equipped with one Silicon Graphics Indy workstation, two Pentium PCS, one 486 PC, two Macs, an inkjet printer, and a color printer. This computing capability is used to model current aircraft as well as new configurations developed by students and/or faculty to meet the changing needs of DoD, in general, and DoN, in particular. The laboratory provides the students with a capstone experience in system design in the many facets of aeronautics, including fixed wing aircraft design, rotary wing aircraft design, and air breathing engine design. Available software includes several design synthesis codes including ACSYNT, AAA, JANRAD, and GASTURB.

All laboratories are supported by the Department's Computational Laboratory, which has a microcomputer network of 25 Silicon Graphics workstations connected to four SUN SPARC-10 fileservers, and one Stardent TITAN 3000 Super workstation. These computers and the CRAY YM-EL at the NPS Computer Center are used for aerodynamics and structural analyses. Access to various supercomputer facilities nationwide is possible from all the Department's workstations by the campus gateway.

FY95 REIMBURSABLE PROGRAM
Department of Aeronautics and Astronautics

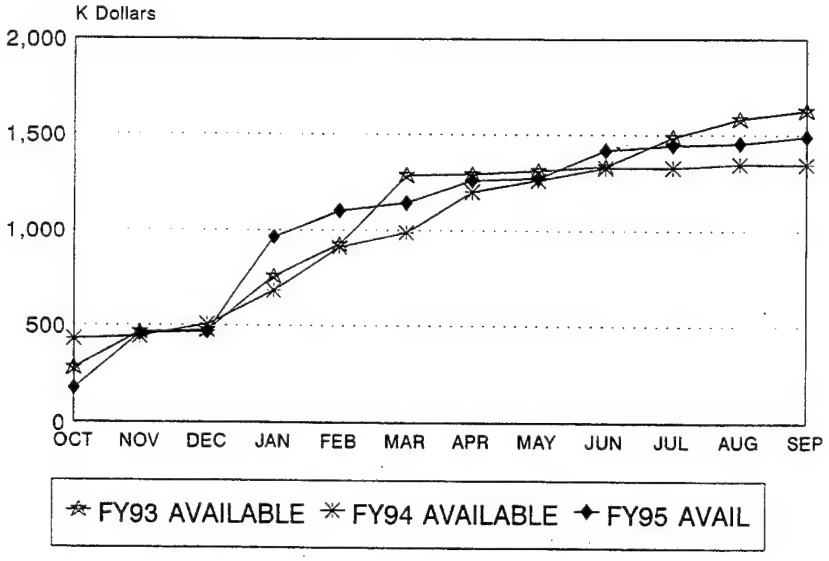

Figure 1. Reimbursable Funds Available by Fiscal Year.
This graph shows the amount of reimbursable funding available to the department. Dollar amounts include research and academic reimbursable activities, as well as funding from Cooperative Research and Development Agreements.

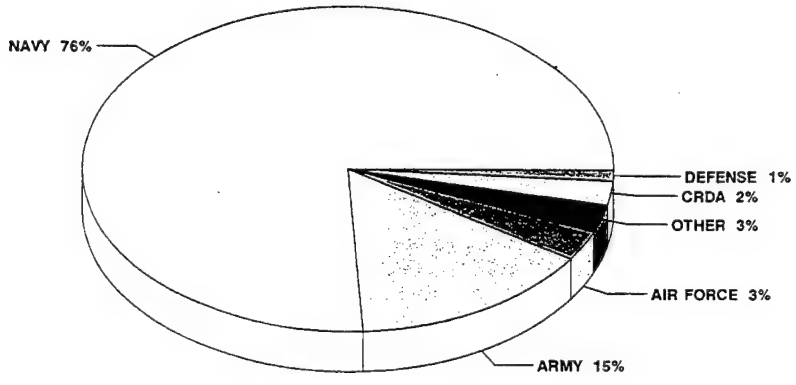

Figure 2. FY95 Reimbursable Sponsor Profile.

AERONAUTICS AND ASTRONAUTICS

NASA ADVANCED DESIGN PROGRAM

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration

OBJECTIVE: The goal of this project was to promote engineering education in space and astronatuics through design.

SUMMARY: Two spacecraft design projects were completed: Tomography Satellite and EHF communications satellite. The mission of the Tomography Satellite was to provide a "near real time" map of the ionosphere. Two different radio waves are sent by the satellite simultaneously and the relative delay of the signals determines electron content along the path of the signal. EHF communications satellite provided EHF communications for mobile tactical users above 65° N latitude, the area not covered by geosynchronous satellites.

DOD KEY TECHNOLOGY AREA: Other (Design Automation)

KEYWORDS: Spacecraft design, communications, ionospheric mapping

SPACECRAFT SYSTEMS

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Space and Navy Warfare System Command

OBJECTIVE: The goal of this project was to develop four spacecraft laboratories at NPS: FLTSATCOM Laboratory, Spacecraft Test Laboratory, Spacecraft Dynamics and Control Laboratory, and Spacecraft Design Laboratory. It is a continuing project.

SUMMARY: During the reporting period, the outstanding achievements were making the vision server optical sensing system operational for Flexible Spacecraft Simulator, development of a new PWPF satellite control algorithms for fine pointing in the presence of structural interactions, integration of FLTSATCOM telemetry and command system, procurement of liquid nitrogen storage tanks for Thermal Vacuum Chamber, and development of the New Computational Spacecraft Design Laboratory and Spacecraft Design Library.

PUBLICATIONS:

Agrawal, B.N. and Bang, H., "Robust Closed-loop Control Design for Spacecraft Slew Maneuver Using Thrusters," Journal of Guidance, Control, and Dynamics, Vol. 18, No. 6, pp 1336-1344, 1995.

Yale, G.E. and Agrawal, B.N., "A Lyapunov Controller for Cooperative Space Manipulators," Journal of Guidance, Control, and Dynamics, accepted for publication.

Bang, H. and Agrawal, B.N., "A Lyapunov Control For Flexible Spacecraft Maneuvers Using Constraint Dynamics," IAF-95-A.7.07, 46th International Astronautical Congress, OSLO, Norway, 2-6 October 1995.

DOD KEY TECHNOLOGY AREA: Other (Design Automation)

KEYWORDS: Spacecraft design, spacecraft attitude control, space manipulators

TOMOGRAPHIC SATELLITE SYSTEM DESIGN

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Security Group Command

OBJECTIVE: The goal of the project was to design a cost-effective satellite system to support a world-wide network of Computerized Ionosphere Topography (CIT) receiving stations.

SUMMARY: A satellite system was designed to meet the object of this project. The constellation was comprised of twelve satellites in four planes. All orbits are circular with an altitude of 1000 km and inclination of 88^0. The satellite had a rectangular shape (35 cm x 35 cm X 150 cm). The total mass of the spacecraft was 75 kg. The payload consisted of two transmitters, a GPS receiver, a CPU, a frequency standard and two quadrifilar helix antennas. Four body mounted silicon solar arrays, one NiH_2 battery made up of 24 cells and power control circuitry comprised the electric power system. Three hydrazine thrusters and two spherical tanks constituted the propulsion subsystem. The primary attitude control was gravity gradient stabilization. Two magnetic torquers and modulated thrusters supported the satellite to keep attitude control during thruster firings. Thermal control is passive.

DOD KEY TECHNOLOGY AREA: Other (Design Automation)

KEYWORDS: Spacecraft system design, tomography, ionosphere

MILITARY USE OF COMMUNICATIONS SATELLITE SYSTEMS

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School, Institute of Joint Warfare Analysis

OBJECTIVE: The goal of the project was to aid the military communications planners in the challenging task of providing enhanced communications capacity in the environment of shrinking budgets.

SUMMARY: The major effort was to analyze the issues related to future MILSATCOM architecture by reviewing over thirty five reports and engaging in discussion with the experts. The guiding principles for MILSATCOM architecture were to structure architecture to provide highest capacity and maximum flexibility, acquire military SATCOM only to provide capabilities not available from commercial infrastructure or when cost effective, and use commercial systems and practices whenever they meet needs economically. These principles resulted in several options. A preliminary design was also performed to provide EHF communications for mobile tactical users above 65^0 N latitude, the area not covered by geosynchronous satellites, such as UHF-Follow-on. The orbit selected was highly elliptical Molniya orbit with inclination 63.40 and period of twelve hours. The payload was the same as on UHF-Follow-On.

PUBLICATION:

Abramson, S. et al, "Design of an Extremely High/Super High Frequency Communications Satellite," AIAA 95-3847, AIAA Space Programs and Technologies Conference, Huntsville, AL, 26-28 September 1995.

DOD KEY TECHNOLOGY AREA: Other (Communications Networking)

KEYWORDS: Communications satellites, satellite architecture

SMART STRUCTURES

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Secretary of the Air Force

OBJECTIVE: The goal of this project was to support the SRDO Smart Structures program by conducting active control of structures with emphasis on modeling, fabrication techniques, sensor and actuator characteristics, and space applications.

SUMMARY: The major efforts were in the survey of the state-of-the-art, vibration suppression and antenna shape control. Several control laws were evaluated to minimize the motion of the tip of the flexible arm of the Flexible Spacecraft Simulator. Multi piezoceramic sensors and actuators were mounted on the flexible beam and a CCD camera was used to measure the motion of the tip of the flexible arm. Analytical model for the shape control of a beam was completed. A finite element model for laminated composite plate with piezoceramic using higher order shear deformation theory was developed. Codes for the model were also written and validated.

PUBLICATIONS:

Agrawal, B. and Bang, H.,"Adaptive Structures for Large Precision Antennas," accepted for publication in ACTA Astronautica.

Bang, H. and Agrawal, B., "Active Vibration of a Deployable Appendages Using Piezoceramic Sensors and Actuators," AAS 95-321, forthcoming at AAS/AIAA Astrodynamics Specialist Conference, Halifax, Nova Scotia, Canada, in August 1996.

Harrington, W. and Agrawal, B.,"The Applications of Smart Structures for Vibration Suppression in Spacecraft," AIAA-95-3848, AIAA 1995 Space Program and Technology Conference, Huntsville, AL, 26-28 September 1995.

CONFERENCE PRESENTATION:

Agrawal, B.N. and Strong, R.E.,"Vibration Suppression of Spacecraft Structures Using H-Infinity Optimized Wave Absorbing Control," VPI&SU Symposium on Structural Dynamics and Control, Blacksburg, VA, 8-10 May 1995.

THESIS DIRECTED:

Harrington, W.,"Experimental Verification of an Optimal Linear Controller for a Flexible Structure," Aeronautical and Astronautical Engineer's Thesis, December 1995.

DOD KEY TECHNOLOGY AREA: Materials, Processes and Structures

KEYWORDS: Smart materials, adaptive structures, vibration isolation

NPS AIRCRAFT SURVIVABILITY SUPPORT

Robert E. Ball, Distinguished Professor
Department of Aeronautics and Astronauts
Sponsor: Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS)

OBJECTIVE: The objective of this effort is to continue the technical support provided to the JTCG/AS for the past 22 years by conducting research, presenting short courses, developing educational material, and performing analyses in aircraft combat survivability. The accomplishments during FY 95 are given below.

SUMMARY:

(1) Educational Materials: Professor Ball continued the development of the second edition of his AIAA textbook, "The Fundamentals of Aircraft Combat Survivability Analysis and Design," American Institute of Aeronautics and Astronautics, 1985, Progress in FY95 consisted of improved rough drafts of the Front Material, Chapter 1 "Introduction", and Appendix A "Probability Theory and Its Application to Survivability Assessment."

(2) Projects: study of the procedures for measuring the effectiveness of military weapons systems was conducted to determine the state of the art. Of particular interest was the contribution of survivability to effectiveness. A procedure that uses a hierarchy or tree which relates many system attributes to the four key attributes of Availability, Reliability, Survivability, and Capability to measure the effectiveness of a system in accomplishing a specified mission.

CONFERENCE PRESENTATIONS:

Ball, R.E. and Atkinson, D.B., "A History of the Survivability Design of Military Aircraft," AIAA 95–1421, 36th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, New Orleans, LA, 10-12 April 1995.

Ball, R.E. and Atkinson, D.B., "History of Air Combat Survivability," JTCG/AS Air Combat Survivability Symposium, Johns Hopkins University, Laurel, MD, 13-15 June 1995.

THESIS DIRECTED:

Brown, K.W., "Measuring the Effectiveness of Weapons Systems in Terms of System Attributes," Master's Thesis, December 1995.

DOD KEY TECHNOLOGY AREAS: Other (Design Automation), Modeling and Simulation

KEYWORDS: Aircraft, survivability, design, modeling, simulation, measures of effectiveness

NPS/NAVAIR SURVIVABILITY AND LETHALITY ASSESSMENT CENTER

Robert E. Ball, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command

OBJECTIVE: The objectives of this research project are: (1) to develop a survivability and lethality assessment center within the NPS Wargaming Analysis & Research Laboratory (WARLAB), and, (2) to use the center to conduct survivability and lethality studies. The computer programs in the center are available to the students and faculty at NPS for research in specific survivability and lethality topics on land, sea, air, and space targets as well as research on the programs themselves.

SUMMARY: The major accomplishments in 1995 were the acquisition and installation of the computer program Modeling System for Advanced Investigation of Countermeasures (MOSAIC) in the WARLAB. The program models the launch and flyout of an infrared missile toward an aircraft that ejects flares. MOSAIC was used by two students in 1995. LT Hardy studied the effects of flares ejected from an F–14A on the miss distance of the AA–11 infrared missile. LCDR Picchini studied the effects of flares from the P–3 aircraft on the miss distance of the AA–7D infrared missile.

THESES DIRECTED:

Hardy, K. P., "MOSAIC (Modeling System for Advanced Investigation of Countermeasures): A Case Study: F–14A Versus AA–11(U)," Master's Thesis, September 1995.

Picchini, T.T,. "A Study of infrared (IR) Flare Decoy Effectiveness for the P–3C ASUW Improvement Program (AIP) Aircraft Against the AA–7D Apex IR Missile(U)," Master's Thesis, September 1995.

DOD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Aircraft, air defense, survivability, lethality, modeling, simulation, infrared missiles, expendables

DEVELOPMENT AND REVIEW OF A SURVIVABILITY TRAINING PLAN

Robert E. Ball, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center – Weapons Division

OBJECTIVE: The objective of this task is to continue the development of a training plan that identifies the training required to develop competency in the discipline of survivability testing and analysis. This plan addresses the needs for both academic and on–the–job training. The plan will coordinate Navy efforts with other ongoing activities, such as training programs associated with the JTCG/AS and JTCG/ME

SUMMARY: This project started in the summer of 1994. Professor Ball's role in this task is to provide information regarding the opportunities for education in survivability and advice regarding the material that should be covered.

DOD KEY TECHNOLOGY AREA: Other (Design Automation)

KEYWORDS: Survivability, susceptibility, vulnerability, test and evaluation

ALTERNATE PROPELLANTS FOR NUCLEAR ELECTRIC PROPULSION

Oscar Biblarz, Professor
Department of Aeronautics and Astronautics
Sponsor: Phillips Labs, Kirkland AFB

OBJECTIVE: The goal of this project is to relate to the Nuclear Electric Propulsion (NEP) space test mission of the AF Phillips Laboratory. Electrical power generation by direct conversion together with electric propulsion are included a bimodal concept for space nuclear reactor utilization.

SUMMARY: The Space Power and Thermal Management Division of the AF Phillips Labs runs a number of programs in which the Naval Postgraduate School is able to contribute expertise. One of these is the TOPAZ II thermionic power generator, purchased from the former USSR and being tested and evaluated by the TOPAZ International Program (TIP). Prior to propulsion applications, the thermionic power generator thermal and electric characteristics as well as the system start-up are being studied and these efforts comprised the effort during this reporting period. It was found that useful power can be produced by the thermionic fuel elements at low heating levels. The test stand for single cell elements (TFE) was investigated and critical thermal resistances identified. Work on a control system to be designed to US standards would benefit from the theory and design presented in LT Astrin's thesis.

PUBLICATIONS:

Benke, S. M. and Venable, J. R., "Operational Testing and Thermal Modelling of a TOPAZ-II Single-Cell Thermionic Fuel Element Stand," Proceedings of Twelfth Symposium on Space Nuclear Power and Propulsion, Albuquerque, NM, 8-12 January 1995.

CONFERENCE PRESENTATION:

Benke, S. M. and Venable, J. R., "Operational Testing and Thermal Modelling of a TOPAZ-II Single-Cell Thermionic Fuel Element Stand," Twelfth Symposium on Space Nuclear Power and Propulsion, Albuquerque, NM, 8-12 January 1995.

THESES DIRECTED:

Venable, J. R., LCDR, USN, "Electrical Characteristics and Thermal Analysis of a TOPAZ-II Single-Cell Thermionic Fuel Element Fuel Stand," Master's Thesis, March 1995.

Astrin, C. D., "Startup Control of the TOPAZ-II Nuclear Reactor," Master's Thesis, December 1995.

OTHER:

Biblarz, O. and Bell, W. J., "Thermionic Arc Breakdown," submitted for publication.

DOD KEY TECHNOLOGY AREA: Other (Propulsion and Energy Conversion)

KEYWORDS: Nuclear electric propulsion, bimodal, thermionic power generation, nuclear controls

MEASUREMENT OF SOOT EMISSIONS

Oscar Biblarz, Professor
David W. Netzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Aircraft Division

OBJECTIVE: Adapt an existing three-wavelength laser extinction measurement system for use with a phase conjugate crystal to minimize atmospheric and beam steering effects on soot mass concentration measurements. Use the instrument in conjunction with a recently NPS developed soot mass concentration measurement technique to measure the soot concentration in simulated engine plumes.

SUMMARY: An instrument was developed and calibrated which is capable of on-line determination of soot concentration in plumes. The instrument utilizes an argon-ion laser, four passes through the exhaust plume using a retroreflector and a phase conjugate crystal to correct for aberrations in the transmitted beam and to increase accuracy when used in low opacity plumes. Several aspects of instrument layout and performance were investigated, and an initial calibration was performed using an ethylene-air combustor. The method requires further development, but shows significant promise for use in a jet engine test cell.

PUBLICATION:

Biblarz, O. and Netzer, D.W., "Determination of Soot Concentration in Plumes from Optical Transmission Measurements," submitted to Journal of Applied Optics.

THESIS DIRECTED:

Turner, P.H., "Particle Sizing in Gas Turbine Exhaust Using a Laser Extinction Technique," Master's Thesis, December 1995.

DOD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Soot concentration, plumes, measurement

A FUNDAMENTAL STUDY OF THE COMPRESSIBILITY EFFECTS ON DYNAMIC STALL OF FIXED AND ADAPTIVE AIRFOILS

M.S.Chandrasekhara, Research Professor
Max F. Platzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Research Office

OBJECTIVE: To study compressibility effects on an airfoil in unsteady motion while it adapts locally to overcome the forces causing unsteady flow separation. The research has applications in active control of helicopter "retreating blade stall." Initiated in April 1994, as a follow-on to the previous research efforts.

SUMMARY: During 1995, the study focused on conducting detailed experimental studies to address one of the major limitations of model-scale testing, namely *Scale Effect*, which is due to differences in Reynolds numbers arising from the vastly different model and prototype sizes. The prohibitively expensive full-scale tests, however, makes model testing worthwhile. One way to address the scale effect is to essentially reproduce the dominating effects that drive the full-scale flow. This is the turbulent boundary layer at full-scale and in this study, a model was tripped by a simple, but highly reproducible trip made from an **address label,** whose leading edge was trimmed by paring scissors to introduce three-dimensional disturbances in the flow to replicate the full-scale flow details. Remarkably good agreement was obtained with an established data set obtained at full-scale. Having thus validated the technique, a new and original data set was obtained at conditions more applicable to a helicopter retreating blade in flight. This study also revealed a new mechanism of dynamic stall, the **shock-induced** dynamic stall for the first time. The interferogram analysis package that was developed for obtaining quantitative pressure distributions was modified significantly so that the singular features of the flow field can be evaluated more accurately using advanced image processing techniques.

PUBLICATIONS:

Chandrasekhara, M.S., Squires, D.D., Wilder, M.C., and Carr, L.W., "A Phase-Locked High-Speed Real-Time Interferometry System for Large Amplitude Unsteady Flows," Experiments in Fluids, Vol. 20, No.2, pp. 61-67, December 1995.

Wilder, M.C., Chandrasekhara, M.S., and Carr, L.W., "Computer-Aided Analysis of Interferometric Images of Unsteady Aerodynamic Flows," ICIASF'95 RECORD, IEEE Publication 95-CH3482-7, pp. 44.1 - 44.11, July 1995.

Ekaterinaris, J.A., Chandrasekhara, M.S., and Platzer, M.F., "Analysis of Low Reynolds Number Airfoil Flows," Journal of Aircraft, Vol. 32, No. 3, pp. 586-593, May-June 1995.

CONFERENCE PRESENTATIONS:

Carr, L.W. and Chandrasekhara, M.S., "A Review of Compressibility Effects on Dynamic Stall of Airfoils," AIAA Paper No. 95-0779, Invited Paper presented at the AIAA 33rd Aerospace Sciences Meeting, Reno, NV, 9-12 January 1995.

Chandrasekhara, M.S., Carr, L.W., and Wilder, M.C., " Unsteady Aspects of Compressible Dynamic Stall Flow at Very Low Pitch Rates," Proceeding 6th Asian Congress of Fluid Mechanics, Singapore, Vol. II, pp. 1528-1531, 22-26 May 1995.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Dynamic stall, helicopter blade stall, interferometry, adaptive wing flow

TESTING OF THREE SPECIAL ARMY AIRFOIL IN THE COMPRESSIBLE DYNAMIC STALL FACILITY

M.S.Chandrasekhara, Research Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Aviation Research and Development Center, Aeroflightdynamics Directorate

OBJECTIVE: To study three special airfoils designed by the U.S. Army laboratory for dynamic stall performance under compressible flow conditions.

SUMMARY: This project was initiated in October 1995. The U.S. Army Aviation Research and Development Center, Aeroflightdynamics Directorate has developed three special helicopter blade sections that have shown dramatic performance characteristics under helicopter flight conditions. The Army laboratory is interested in building a helicopter rotor using this blade section profile and test fly the helicopter. However, the performance of the blade sections under dynamic stall conditions, especially at compressible Mach numbers is unknown at this time. The purpose of the project is to obtain this information using non-intrusive optical diagnostic methods and quantify the flow field using the in-house developed interferogram analysis capabilities. In particular, the stall-free performance of the airfoils observed in low speed testing needs to be assessed at high speeds. The airfoils and mounting mechanisms are now in hand and the necessary fabrication to achieve proper fit with the existing tunnel glass windows has been completed. Testing will commence in CY 96

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Stall-free airfoils, flow control

FAN AND COMPRESSOR STALL

Garth V. Hobson, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Aircraft Division

OBJECTIVE: To perform detailed laser-Doppler-velocimetry (LDV) measurements in a low speed cascade tunnel of Controlled-Diffusion (CD) compressor blades at stall.

SUMMARY: LDV measurements were repeated in the cascade of CD blades at stall. These measurements were performed after the tunnel had been reconfigured twice. The purpose of repeating the experiment was to determine whether the stall situation in the tunnel could once again be simulated.

These measurements ended more than a decade of testing on these blades, which allowed a new set of second-generation CD blades to be installed in the tunnel. Initial design point operation measurements of the blade performance were obtained.

Initial test on a set of second generation CD blades were completed at design conditions. These entailed LDV, loss and blade surface pressure measurements.

PUBLICATIONS:

Hobson, G.V., "Computation of End-Wall Flow in a Linear Cascade and Comparison with Experiment," accepted for publication and presentation at the 1995 ASME San Francisco Meeting.

Hobson, G.V., Wakefield, B.E., and Roberts, W.B., "Turbulence Amplification with Incidence at the Leading Edge of a Compressor Cascade," accepted for presentation at the 1996 IGTI Conference in Birmingham, UK.

THESES DIRECTED:

Hansen, D.J., "Investigation of Second Generation Controlled-Diffusion Compressor Blades in Cascade," Master's Thesis, September, 1995.

Williams, A. J. H., "Laser-Doppler Velocimetry and Viscous Flow Computation of the Flow Through a Compressor Cascade Near Stall," Master's Thesis, June 1995.

OTHER:

Hobson, G.V., Ganaim Rickel, H.J. and Williams, A.J.H., "Laser-Doppler Velocimetry and Flow Visualization of Flow Through a Compressor Cascade at Stall," recommended for publication in the ASME Journal of Turbomachinery.

DOD KEY TECHNOLOGY AREA: Other (Propulsion and Energy Conversion)

KEYWORDS: Controlled-diffusion blade stall, LDV measurements, compressor cascade stall

SPACE SHUTTLE MAIN ENGINE TURBINE PERFORMANCE MEASUREMENTS

Garth V. Hobson, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: This research project is aimed at obtaining performance measurements in a turbine for the High Pressure Fuel TurboPump (HPFTP) of the Space Shuttle Main Engine (SSME). Eventually the aim is to be able to measure the tip leakage vortex flowfield in the turbine with a three-component laser-Doppler velocimeter (LDV).

SUMMARY: The data acquisition system in the high speed building of the TPL was upgraded to a PC-based graphical system. With this extensive data acquisition system, performance measurements were performed on the turbine. These included turbine exit probe surveys and throttle valve control via the data acquisition system. The project also included the design and manufacture of the exit throttle valve for the turbine.

THESIS DIRECTED:

Greco, P. A., "Turbine Performance Mapping of the Space-Shuttle Main Engine High-Pressure Fuel Turbopump," Master's Thesis, September 1995.

DOD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Laser doppler velocimetry, turbine

TURBINE TIP-LEAKAGE FLOWS

Garth V. Hobson, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Aircraft Division

OBJECTIVE: The objective of this project is to develop techniques necessary to obtain non-intrusive LDV data in the tip-leakage region of operating turbines, as these flows account for significant losses. The problems associated with optical access windows and seeding material are to be addressed in an annular turbine cascade (ATC), and then LDV measurements will be performed in the turbine of the High Pressure Fuel TurboPump (HPFTP) for the Space Shuttle Main Engine (SSME).

SUMMARY: This project entails the systematic measurements of highly swirling turbine flows, with a three-component fibre-optics laser Doppler velocimeter (LDV), in test articles of small size at realistic Mach numbers.

Accomplished this year were blade surface pressure measurements in the cascade at various pressure ratios from subsonic to sonic exit conditions. Comparisons were made between these measurements and with a full 3-D CFD simulation of the flowfield. Detailed LDV measurements were performed in the endwall region downstream of the cascade, at a subsonic exit Mach number. These measurements were also through a one mm hole in the outer casing, at increasing radial depths and at different circumferential positions.

THESIS DIRECTED:

Donovan, W. H., "Experimental and Computational Investigation of Flow Through an Annular Turbine Cascade," Master's Thesis, June 1995.

DOD KEY TECHNOLOGY AREA: Other (Propulsion Computational Fluid Dynamics)

KEYWORDS: Turbine, doppler velocimetry, turbulence

A COMPARISON OF FLIGHT INPUT TECHNIQUES FOR PARAMETER ESTIMATION OF HIGHLY-AUGMENTED AIRCRAFT

Richard M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration

OBJECTIVE: The objective of this project was to improve the estimation of aerodynamic parameters at high angles of attack by comparing the responses from various classical and modern optimal flight inputs through the use of uncertainty analysis in a parameter-estimation method.

SUMMARY: Recent techniques have been devised for the optimal design of flight inputs for the estimation of stability-and-control derivatives for aircraft at high angles of attack. It was desired to perform a comparison of the results from the new optimal techniques with those of more traditional sequential single-surface inputs. Two optimal input techniques, a single-surface input (SSI) technique using an onboard excitation system, and the classical doublet technique were flown on the F-18 HARV aircraft at the NASA Dryden Flight Research Center. A widely-used parameter-estimation method, pEst, was used for the data analysis and to predict estimations of the Cramer-Rao bounds for each method. The Cramer-Rao bounds provide an estimate of the expected error of the predicted aerodynamic derivatives. It was found that the automated SSI technique provided the smallest Cramer-Rao bounds, and that deflecting each control surface separately significantly decreased the undesirable correlation between the input control surfaces.

THESIS DIRECTED:

Gates, J.G., "A Comparison of Flight Input Techniques for Parameter Estimation of Highly-Augmented Aircraft," Master's Thesis, September 1995.

OTHER:

Paper submitted to the 1996 AIAA Atmospheric Flight Mechanics Conference.

DOD KEY TECHNOLOGY AREAS: Air Vehicles, Human Systems Interface, Modeling and Simulation

KEYWORDS: Parameter estimation, flight test, parameter identification, highly-aumented aircraft

ON DESIGN AND IMPLEMENTATION OF NONLINEAR GAIN-SCHEDULED CONTROLLERS FOR MANNED AND UNMANNED VEHICLES

Isaac I. Kaminer, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School and 1994-1995 North Atlantic Treaty Organization (NATO) Fellowship

OBJECTIVE: The goal of this project is to develop efficient techniques for designing and implementing gain-scheduled controllers for nonlinear plants. In particular, the designing of trajectory tracking controllers for autonomous underwater and air vehicles.

SUMMARY: The work covered by this project addresses the problem of integrated design of guidance and control systems for autonomous vehicles (AVs). In fact, a new methodology was developed for integrated design of guidance and control for autonomous vehicles. The methodology proposed leads to an efficient procedure for the design of controllers for AVs to accurately track reference trajectories defined in an inertial reference frame. This methodology was applied to the design of a tracking controller for the Unmanned Air Vehicle Bluebird at the NPS UAV Lab and to the Autonomous Underwater Vehicle Marius at the Instituto Superior Tecnico of Lisbon, Portugal.

PUBLICATIONS:

Kaminer, I., Pascoal, A.M., Khargonekar, P.P., and Coleman, E., "A Velocity Algorithm for the Implementation of Nonlinear Gain-Scheduled Controllers," Automatica, Vol. 31, pp. 1185-1191, 1995.

Fryxell, D., Oliveira, P., Pascoal, A., Silvestre, C., and Kaminer, I., "Navigation, Guidance and Control of AUVs: An Application to the MARIUS Vehicle" to appear in the March issue of IFAC Journal of Control Engineering Practice, 1996.

Niewhoener, R.J. and Kaminer, I., "Design of an Autoland Controller for F-14 Aircraft Using H_infinity Synthesis," to appear in AIAA Journal of Guidance and Control.

Niewhoener, R.J. and Kaminer, I., "On Integrated Aircraft/Controller Design Using Linear Matrix Inequalities," to appear in AIAA Journal of Guidance and Control.

Costello, D., Kaminer, I., Carder, K., and Howard, R., "The Use of Unmanned Vehicle Systems for Coastal Ocean Surveys: Scenarios for Joint Underwater and Air Vehicle Missions," Proceedings of 1995 Workshop on Intelligent Control of Autonomous Vehicles, Lisbon, Portugal, pp. 61-72, March 1995.

Fryxell, D., Oliveira, P., Pascoal, A., Silvestre, C., and Kaminer, I., "Navigation, Guidance and Control of AUVs: An Application to the MARIUS Vehicle," Proceedings of 1995 IFAC Control Applications in Marine Systems Conference, Oslo, Norway, 1995.

Silvestre, C., Pascoal, A., Fryxell, D., and Kaminer, I., "Design and Implementation of a Trajectory Tracking Controller for an Autonomous Underwater Vehicle (AUV)," Proceedings of 1995 American Control Conference, Seattle, WA, June 1995.

Kaminer, I., Hallberg, E., Pascoal, A., and Silvestre, C., "On the Design and Implementation of a Trajectory Tracking Controller for a Fixed Wing Unmanned Air Vehicle," Proceedings of 1995 American Control Conference, Seattle, WA, June 1995.

Howard R.M. and Kaminer. I, "Survey of Unmanned Air Vehicles," Proceedings of 1995 American Control Conference, Seattle, WA, June 1995.

CONFERENCE PRESENTATIONS:

Kaminer, I., "On Integrated Aircraft/Controller Design Using Linear Matrix Inequalities," 1995 American Control Conference, Seattle WA, 21-23 June 1995.

Kaminer, I., "Unmanned Air Vehicles: A Survey ," 1995 American Control Conference, Seattle WA, 21-23 June 1995.

Kaminer, I., "On the Design and Implementation of a Trajectory Tracking Controller for a Fixed Wing Unmanned Air Vehicle," 1995 American Control Conference, Seattle WA, 21-23 June 1995 .

THESES DIRECTED:

Berglund, E., "An Integrated Approach to the Design of Aircraft Gain Scheduled Controller," Engineer's Thesis, March 1995.

Kataras, D.E., "Design and Implementation of Inertial Navigation System for Real Time Flight of an Unmanned Air Vehicle," Master's Thesis, March 1995.

Christofis, A., "On Design and Analysis of a Differential Global Positioning System (DGPS) Aided Navigation System for Unmanned Airborne Vehicle," Master's Thesis, June 1995.

Hakun, G., "Operation of Untethered Unmanned Air Vehicle," Master's Thesis, September 1995.

DOD KEY TECHNOLOGY AREAS: Air Vehicles, Modeling and Simulation

KEYWORDS: Flight control systems, gain-scheduled controllers, nonlinear control, robust control, guidance and control

MARITIME AVIONICS SUBSYSTEMS AND TECHNOLOGY PROGRAM (MAST)

Isaac I. Kaminer, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command

OBJECTIVE: To perform research and development in advanced avionics technology topics relevant to NAVAIR MAST program.

SUMMARY: Over past several years under NAVAIR sponsorship, NPS has embarked on the development and evaluation of GPS/INS integration systems. In particular, progress has been made in the development of the uniform framework for the INS/GPS integration using Kalman Filtering. The work is ongoing and strives to unify various approaches to the development of INS systems and their integration with GPS using Kalman Filtering.

THESIS DIRECTED:

Herrington, J.B., "Uniform Framework for GPS/IMU Integration Using Kalman Filtering," Master's Thesis, June 1995.

DOD KEY TECHNOLOGY AREAS: Other (Avionics), Modeling and Simulation

KEYWORDS: GPS, inertial navigation, Kalman Filtering

ON DEVELOPMENT OF HSCT TAIL SIZING CRITERIA

Isaac I. Kaminer, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration

OBJECTIVE: To Develop Tail Sizing Criteria for High Speed Civil Transport.

SUMMARY: This work was done as a part of NASA/ASEE Summer Faculty Fellowship Program at the Langley Research Center. It determined the HSCT tail sizing criteria using newly developed integrated aircraft/controller design methodology (the methodology was developed together with R. Niewoehner, Ph.D. student). The key idea was to rewrite the tail sizing and feedback requirements as Linear Matrix Inequalities. In particular, the effects of feedback specifications, such as MIL STD 1797 Level I and II flying qualities requirements, and of actuator amplitude and rate constraints on the maximum allowable cg travel for a given set of tail sizes were considered. A static state feedback controller was designed as a part of the tail sizing process.

OTHER:

Kaminer I., Howard R.M., and Buttrill C., "On the Development of HSCT Tail Sizing Criteria," submitted to 1996 AIAA Conference on Guidance and Control.

DOD KEY TECHNOLOGY AREA: Other (Flight Controls)

KEYWORDS: Tail sizing, robust control, optimization

LETHAL UNMANNED AIR VEHICLES FEASIBILITY STUDY

Isaac I. Kaminer, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Unfunded

OBJECTIVE: Investigate the feasibility of using Unmanned Air Vehicles to detect and destroy mobile missile launchers.

SUMMARY: In the recent study conducted by Professor Kneale Marshal of the Operations Research Department at NPS, the authors have shown that the most effective way to deal with ballistic missiles (like the SCUDS used by Iraq in the Gulf War) is to destroy the mobile missile launchers before the missile is launched. Motivated by these results, a SIMULINK/MATLAB simulation was developed to study the technical issues involved in using UAVs to accomplish this task. Furthermore, we conducted a survey of existing UAV systems to identify a platform most suitable to detect and destroy mobile missile launchers.

THESES DIRECTED:

Green, J.K. Jr., "Lethal Unmanned Vehicles Feasibility Study," Master's Thesis, September 1995.

Kammann R.W., "Computer Modeling and Simulation of a Theater Ballsitic Missile (TBM) Counterforce Plan Involving a Lethal UAV," Master's Thesis, September 1995.

DOD KEY TECHNOLOGY AREAS: Air Vehicles, Modeling and Simulation

KEYWORDS: Lethal UAVs, guidance and control

JSOW UNITARY CAPTIVE AIR TRAINING MISSILE (CATM) CONCEPTUAL DESIGN

Gerald H. Lindsey, Professor
Oscar Biblarz, Professor
Isaac Kaminer, Assistant Professor
Sandra Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command

OBJECTIVE: To perform conceptual design studies on a Captive Air Training Missile for the JSOW unitary missile and explore possibilities of extending its applicability to other missiles.

SUMMARY: Work was begun by forming a JSOW design team of students from the 610 and 611 curricula who were interested in the project as possible thesis research. Five students from four disciplines of aeronautical engineering have now identified thesis problems and are at work on those problems. Three more students are attending JSOW team meetings and are planning to do thesis research on the project, but they have not yet entered the research phase of their curriculum. Work has gone forward under faculty direction in the following areas:

1. Using the expertise of the F/A-18 pilots, a Concept of Operations has been developed for the CATM, from which will flow the Functional Requirements and ultimately the Performance Requirements, which are all deliverables.

2. A thorough scrutiny and comparison of CATM operations with JSOW Unitary operations was begun to identify all differences that must be considered in the design of the CATM to insure that it is a faithful simulation of the missile.

3. Airframe structural layout and initial weight estimates were begun. Physical shape configuration studies have been started, with front end and aft end driving considerations being studied to determine desirable contours and length requirements, as well as wing location parameters.

4. Computer simulation of the missile flight, using aerodynamic characteristics of the JSOW Unitary, has been undertaken. This involves determining the actual trajectory of the missile through programmed way points all the way to the target. The result will be used to design guidance, navigation, and control systems for the JSOW, which in turn will be used to develop avionic training aids for the F/A-18 in line with the concept of operations.

The project has just begun and is funded through the remainder of FY '96, and it is hoped that funding will continue into the following fiscal year. Products of the study will be theses and technical reports written to NAVAIR PMA-201 and via them to Texas Instruments, who is the prime contractor for the project. CATM design and development phase is due to begin in FY 1999.

DOD KEY TECHNOLOGY AREAS: Air Vehicles, Conventional Weapons

KEYWORDS: Missile, missile design, JSOW, CATM, pilot training

DESIGN AND DEMONSTRATION OF A SMALL, LOW-COST SUPERSONIC MISSILE FOR LETHAL UAV AND HELICOPTER APPLICATIONS

David W. Netzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Ballistic Missile Defense Office

OBJECTIVE: To determine the feasibility of a small, low-cost, caseless, hybrid-booster/solid-fuel ramjet sustain missile propulsion system that utilizes a common fuel grain and has no ejectables.

SUMMARY: Performance of an air-to-ground missile with a solid propellant booster and solid fuel ramjet (SFRJ) sustainer, capable of being fired from an unmanned aerial vehicle or helicopter was obtained using an Air Force/JANNAF computer code. A hybrid booster/SFRJ (H/SFRJ)sustainer motor was then designed analytically and compared to the generated computer output. The results showed that a H/SFRJ that has performance equal to a solid-booster SFRJ is feasible. The final missile design had a range of 20 nm, a flight Mach number of 2.0, a diameter and length of 5 and 99 inches respectively, and weighed 82 pounds. Caseless hybrid rockets with erodible nozzles were tested to validate assumptions made in the design analysis. In addition, transition from hybrid-rocket booster to solid-fuel ramjet sustainer was demonstrated.

THESIS DIRECTED:

Woods, P.C., "Integral Hybrid-Boost/Solid-Fuel Ramjet Propulsion for Lightweight Tactical Missiles," Engineer's Thesis, December 1995.

DOD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Combined Cycle Propulsion, hybrids, solid fuel ramjets

PERFORMANCE OPTIMIZATION FOR LIQUID-FUEL RAMJETS

David W. Netzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Weapons Division

OBJECTIVE: To determine optimum inlet dump configurations with and without the use of aerogrids. To evaluate the combustion characteristics of new, high energy-density fuels and fuel additives.

SUMMARY: Four variations of a single-side inlet-dump ramjet combustor were examined using laser Doppler velocimetry and laser sheet flow visualization in a water tunnel. Aerogrids were found to reduce the size of recirculation zones, eliminate the large-scale vortices shed from the inlet dump and increase fine-scale mixing. These effects should result in increased combustion efficiency and minimum combustion instability, but at the expense of narrower flammability limits and increased pressure losses. Two different scalloped inlets were investigated for providing the benefits of the aerogrid with reduced disadvantages. A geometry which produced high-amplitude, low frequency flow structures showed promise but further optimization is required. The burning rates and characteristics of several high energy liquid fuels, including JP-10, RJ-7, Mobil E-5 and JP-8, and of high-octane, high flash point solvents were determined using a windowed combustion bomb at pressures from 1-10 atm, a video camera and a frame grabber. Atomization characteristics were measured using a poppet atomizer and a Malvern particle analyzer. Mobil E-5 and RJ-7 had higher burning rates and higher volumetric heating rates than JP-10. The solvents had adequate burning rates, but increased sooting characteristics due to high C/H ratios. Smoke suppressant additives may improve the overall performance of these solvents. 0.6% by volume of an inexpensive, commercially available fuel additive in kerosene was found effective for reducing plume IR signature in a motor burning kerosene and oxygen. At an equivalence ratio of 2.0 and a pressure of 1.4 MPA the plume soot concentration was reduced by 65% and the average plume radiance by 82% in the 3.5-5μ band. The size distribution and optical properties of the soot were not significantly altered. Combustion efficiency was maintained between 93-96%.

CONFERENCE PRESENTATION:

Netzer, D.W., "Solid and Liquid Fuel Ramjet Research at the Naval Postgraduate School," U.S./France Data Exchange Agreement (D.E.A.) Meeting on Ramjet and Combined Engines Propulsion Technology, Monterey, CA, 13-21 July 1995.

THESES DIRECTED:

Stevens, M.L., "Flow Visualization and Optimization of Side-Inlet-Dump Liquid-Fuel Ramjet Combustors," Master's Thesis, December 1995.

Reber, K.L., "Burning Rates and Atomization Characteristics of Liquid Hydrocarbon Fuels," Master's Thesis, December 1995.

Swenson, A.W., "Liquid Hydrocarbon Fuel Composition Effects on Plume Characteristics," Master's Thesis, December 1995.

DOD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Ramjet combustors, inlets, fuel performance

THE EFFECTS OF PARTICULATES ON SUPERSONIC SHEAR LAYERS AND AFTERBURNING IN FUEL-RICH PLUMES

David W. Netzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Office of Naval Research

OBJECTIVE: To quantify the effects of solid propellant rocket motor exhaust particulates and motor operating conditions on supersonic shear layers, the effectiveness of mixing enhancement techniques and the resulting afterburning.

SUMMARY: Three techniques for enhanced mixing in supersonic plumes were investigated; nozzle exit tabs, annular cavities at the nozzle exit and a lobed nozzle. The effectiveness of the devices for significantly changing the extent of afterburning was first evaluated by exhausting hot, fuel-rich, supersonic gaseous flows into the atmosphere and recording the plume temperature distribution using a thermal imaging camera. Laser-sheet flow visualization was also used to examine the resulting effects on the mixing and/or jet spreading rate. The devices were then used in an exhaust nozzle of a rocket motor that utilized both a highly aluminized propellant and a minimum-smoke propellant to determine whether or not the particulate affect the mixing process/afterburning. The exit tabs and lobed nozzle were found effective for changing the afterburning structure under the high exit Mach number conditions typical of tactical motors. Malvern measurements across the plume showed that most of the volume (mass) of particulate was in particles with diameters between 4 and 5.5 microns. However, practically all of the number of particles had diameters smaller than 1.9 microns. A phase-Doppler particle analyzer (PDPA) in conjunction with multiple-wavelength extinction measurements were also used in a specially designed particle collection probe. The PDPA and Malvern measured distributions agreed in the observed modes near 1 and 4.5 microns. Scanning electron microscope pictures of collected particles were in good agreement with the measured Malvern Sauter mean diameter of 2.6 microns. Less than 3% of the total mass of particulates was found to be contained in particles with diameters less than 0.5 microns. Therefore, PDPA measurements alone can be used to determine the particle size distribution with good accuracy. The generation of axial vortices in the supersonic shear layers at the nozzle exit of rocket motors operating with characteristically high exit Mach numbers and temperatures can enhance the mixing rates and affect the afterburning for gaseous flow. Initial data have shown that the presence of large quantities of small particulate in the plume may significantly change the results obtained using enhanced mixing devices.

PUBLICATION:

Lee, S.R. and Netzer, D.W., "The Effects of Particulates on Supersonic Shear Layers and Afterburning in Fuel-Rich Plumes," Proceedings of the 8th ONR Propulsion Meeting, Roy, G.D. and Williams, F.A., eds., pp. 327-335, 1995.

CONFERENCE PRESENTATIONS:

Lee, S.R. and Netzer, D.W., "The Effects of Particulates on Supersonic Shear Layers and Afterburning in Fuel-Rich Plumes," 8th ONR Propulsion Meeting, La Jolla, CA, 11-13 October 1995.

Lee, S.R. and Netzer, D.W., "The Effects of Particulates on Supersonic Shear Layers and Afterburning in Fuel-Rich Plumes," 22nd JANNAF Exhaust Plume Technology Subcommittee Meeting, Huntsville, AL, 23-27 October 1995.

THESES DIRECTED:

Manser, J.R., "Solid Rocket Motor Plume Particle Size Measurements Using Multiple Optical Techniques in a Probe," Master's Thesis, March 1995.

Lee. S.R., "The Effects of Particulates on Supersonic Shear Layers and Afterburning in Fuel-Rich Plumes," Master's Thesis, December 1995.

DOD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Rocket plumes, mixing, particulate

THE NASA/USRA UNIVERSITY ADVANCED DESIGN PROGRAM IN AERONAUTICS AT THE NAVAL POSTGRADUATE SCHOOL

Conrad F. Newberry, Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration

OBJECTIVE: The goal of the NASA/USRA University Advanced Design Program in Aeronautics is to improve and enhance aeronautical design instruction at the Naval Postgraduate School. Calendar fiscal year 1995 is the reporting period for this continuing instructional enhancement research effort.

SUMMARY: The primary focus of the advanced design program of instruction is the innovative design of deck-launched waverider configured aircraft. However, due to student interest, conventional aircraft, helicopter, aircraft engine and missile system design projects were also completed. Automated design tools were both developed and purchased. Student aircraft, missile and helicopter design products were entered in national competitions. Thesis research efforts in low-speed waverider aerodynamic and performance characteristics supported design class projects. One Pentium PC and one color printer were purchased to enhance the quality and effectiveness of the design laboratory supporting aircraft, missile, engine and helicopter aeronautical design.

PUBLICATION:

Newberry, C.F., "The Conceptual Design of Deck-Launched Waverider Configured Aircraft," Preprint AIAA-95-6155, AIAA Sixth International Aerospace Planes and Hypersonics Technologies Conference, Chattanooga, TN, 3-7 April 1995.

CONFERENCE PRESENTATION:

Burris, S., "1993/1994 AIAA McDonald Douglas Corporation Graduate Team Aircraft Design Competition - Maritime Patrol Strike Aircraft," 1st AIAA Aircraft Engineering, technology, and Operations Congress, Los Angeles, CA, 19-21 September 1995.

DOD KEY TECHNOLOGY AREA: Other (Integrated System Design)

KEYWORDS: Waverider, strike, design integration, subsonic, supersonic, aerodynamic testing and hypersonic

LOW-SPEED AERODYNAMIC ANALYSIS OF A WAVERIDER CONFIGURED MODEL

Conrad F. Newberry, Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration - Ames Research Center

OBJECTIVE: The goal of this project is to determine the low-speed vortex flow, lift, drag and pitching moment characteristics of a M_∞=6 waverider design. Calendar/fiscal year 1995 is the reporting period for this continuing research effort.

SUMMARY: During calendar year 1995, low-speed subsonic tests of a fifteen inch root chord model were performed in one of the low-speed subsonic NPS wind-tunnels. Lift, drag and pitching moment data were recorded during the subsonic wind tunnel tests.

The wind tunnel studies confirm that the Price waverider has a lift-curve slope approximately of $C_{L_\alpha} = 0.053$ per degree and stalls at approximately α=30°. The slope of the pitching moment versus angle-of-attack curve tends to be positive, suggesting that the basic configuration is statically unstable. The Price waverider drag polar exhibits the expected smooth parabolic slope with a minimum drag coefficient of approximately $C_{D_o} = 0.02$. John Murray performed tests which showed that the test results of Mark Cedrun were generally repeatable.

DOD KEY TECHNOLOGY AREAS: Other (Design Automation), Aerospace Propulsion and Power

KEYWORDS: Waverider, design integration, flowfield visualization, subsonic, supersonic, aerodynamic testing and hypersonic

AIRCREW-CENTERED SYSTEM DESIGN

Conrad F. Newberry, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command

OBJECTIVE: Define the attributes and characteristics of an Aircrew-Centered System Design discipline.

SUMMARY: A number of recent initiatives have been implemented to alleviate problems which arise as modern tactical aircraft and cockpits have come to overwhelm the aircrew. Further initiatives have been identified to further ameliorate aircrew work and/or information overload. These recent and future initiatives are briefly summarized herein.

1. An Aircrew-Centered System Design (ACD) invitational workshop was held at the Naval Postgraduate School (NPS) on 16-18 May 1995 to address mission-effective crewstation cognitive and workload requirements.

2. At the request of the JAST program, Requirements Office, a one day workshop was held at NPS on 19 May 1995, following the ACD workshop. This workshop focused on the application of aircrew-centered design concepts to the planned JAST ASAP (Aircrew System Assessment Panel) and Virtual Strike Warfare efforts.

3. An initiative is underway to create an Aircrew System Design Technical Committee within the American Institute of Aeronautics and Astronautics (AIAA) which will focus professional attention on the impact of aircrew system requirements on the conceptual, preliminary and detailed design, flight test and operation of aircraft.

CONFERENCE PRESENTATION:

Newberry, C.F., "Aircrew-Centered System Design," 35th Department of Defense Human Factors Engineering Technical Advisory Group (TAG), Monterey, CA, 6-9 November 1995.

OTHER:

An Aircrew-Centered System Design Working Group within AIAA was established with C.F. Newberry as the chairman.

DOD KEY TECHNOLOGY AREA: Other (Integrated System Design)

KEYWORDS: Aircrew, design integration, system design

HIGH LIFT STUDIES FOR ENHANCED FIGHTER MANEUVERABILITY

Max F.Platzer, Professor
Sheshagiri K.Hebbar, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Aircraft Division

OBJECTIVE: Identify promising methods for the generation and exploitation of dynamic lift in order to achieve enhanced fighter aircraft maneuverability. To this end, perform detailed experimental studies on double delta wings and canard-wing configurations.

SUMMARY: Water tunnel flow visualization studies were conducted to determine the effect of fillets on the vortex development over cropped double-delta wings.

PUBLICATIONS:

Hebbar, S.K., Platzer, M.F., and Frink, W.D., "Effect of LEX Fences on the Vortex Wake of an F/A-18 Model," Journal of Aircraft, Vol. 32, No. 3, pp. 680-682, May-June 1995.

Hebbar, S.K., Platzer, M.F., and Liu, D.M., "Effect of Canard Oscillations on an X-31-Like Model in Pitching Maneuver," Journal of Aircraft, Vol. 32, No. 5, pp. 1157-1160, September-October 1995.

CONFERENCE PRESENTATION:

Hebbar, S.K., Platzer, M.F., and Al-Khozam, A., "Experimental Investigation of Vortex Flow Control Using Juncture Fillets on a Cropped Delta Wing," AIAA Paper 95-0649, 33rd Aerospace Sciences Meeting, Reno, NV, 9-12 January 1995.

OTHER:

Fritzelas, A., "A Water Tunnel Investigation of the Reynolds Number Effect on High-Incidence Flow over Double-Delta Wings," Master's thesis forthcoming in 1996.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: High-lift aerodynamics, vortical flows

NUMERICAL INVESTIGATION OF HIGH ANGLE OF ATTACK MISSILE AERODYNAMICS

Max F. Platzer, Professor
John A. Ekaterinaris, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Weapons Division

OBJECTIVE: Develop Navier-Stokes solutions for the vortical flow over complete missile configurations in steady

or maneuvering high angle of attack flight.

SUMMARY: Navier-Stokes computations were completed for subsonic flow over delta wings and over a complete missile configuration at high angle of attack. Also, force and moment data were acquired on a NAWC-designed missile.

PUBLICATIONS:

Tuncer, I.H., Ekaterinaris, J.A., and Platzer, M.F., "A Novel Viscous-Inviscid Interaction Method for Unsteady Low-Speed Airfoil Flows," AIAA Journal, Vol. 33, No. 1, pp. 151-154, January 1995.

Coutley, R.L., Ekaterinaris, J.A., Schiff, L.B., and Platzer, M.F., "Navier-Stokes Computation of the Flow over a Double-Delta Wing at High Incidence," Journal of Aircraft, Vol. 32, No. 3, pp. 457-463, May-June 1995.

Ekaterinaris, J.A., Chandrasekhara, M.S., and Platzer, M.F., "Analysis of Low Reynolds Number Airfoil Flows," Journal of Aircraft, Vol. 32, No. 3, pp. 625-630, May-June 1995.

Hebbar, S.K., Platzer, M.F., Smith, E.H., and Salazar, M.E., "High Angle of Attack Wind Tunnel Investigation of a Multi-Mission Vehicle," Journal of Spacecraft and Rockets, Vol. 32, No. 4, pp. 734-736, July-August 1995.

CONFERENCE PRESENTATION:

Gutmark, E.J., Yu, K.H., van Dyken, R.D., Tuncer, I.H., and McLachlan, B.G., "Experimental and Computational Study of a Close-Coupled Canard-Wing Configuration at High Angle of Attack," AIAA Paper 95-1863, 13th Applied Aerodynamics Conference, San Diego, CA, 19-22 June 1995.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Missile aerodynamics, vortical flows, computational fluid dynamics

SMALL-SCALE INVESTIGATION OF JET-INDUCED GROUND EFFECTS

Max F. Platzer, Distinguished Professor
Sheshagiri K. Hebbar, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration - Ames Research Center

OBJECTIVE: Perform small-scale flow visualization tests to determine the jet-induced ground effects and the effect of support struts on fountain formation relevant to ASTOVL aircraft.

SUMMARY: The flow visualization tests showed that the proposed strut configurations had only a minor aerodynamic interference effect.

CONFERENCE PRESENTATION:

Hebbar, S.K., Platzer, M.F., and Dooley, W., "Ground Effect Studies on STOVL Aircraft in Hover," Proceedings of 6th Asian Congress of Fluid Mechanics, Singapore, pp. 194-197, 22-26 May 1995.

THESIS DIRECTED:

Kristy, M.H., "Strut and Wall Interference on Jet-Induced Ground Effects of a STOVL Aircraft in Hover," Master's Thesis, September 1995.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Aircraft aerodynamics, short take-off and landing aircraft, ground interference effects

EXPERIMENTAL STUDY OF BOUNDARY LAYER ENERGIZATION

Max F. Platzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Office of Naval Research

OBJECTIVE: The objective of the proposed effort is the exploration and demonstration of a new boundary layer acceleration and flow control device.

SUMMARY: Water tunnel tests showed that the use of flapping airfoils is a promising method of suppressing flow separation.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics/Hydrodynamics)

KEYWORDS: Drag reduction, flow control, boundary layers

ADVANCED MULTIDISCIPLINARY ANALYSIS AND DESIGN OPTIMIZATION METHODS FOR SUBSONIC TRANSPORT AIRCRAFT

Max F. Platzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: McDonnell-Douglas Aircraft Company

OBJECTIVE: To contribute to the development of advanced multidisciplinary analysis and design optimization methods for subsonic transport aircraft.

SUMMARY: This work entails the use/extension of three-dimensional computational fluid dynamics codes for viscous subsonic/transonic flow over a wing/body/nacelle/pylon configuration and the development of new turbulence models. Also, it involves the use of a finite element code to determine the aircraft deformation under loading and to speed up the computations by means of parallelization.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics/Structures)

KEYWORDS: Aerodynamics, computational fluid dynamics, structures, finite element modelling, design optimization

OPTIMAL PERIODIC CONTROL FOR LOW-EARTH-ORBIT MAINTENANCE

I. Michael Ross, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: This proposal was aimed at analyzing fuel-optimal periodic maneuvers necessary to keep a large low-Earth-orbiting satellite within a prescribed altitude band. In particular, the utilization of optimal control theory to analyze the fuel-efficiency of a "forced Keplerian trajectory (FKT)."

SUMMARY: Extremal singular arcs for a low-Earth-orbiting spacecraft were derived and the results were used to formulate the fundamental problem of orbit maintenance. It was shown that nonoptimal steering induces singular control and this lead to the discovery of steering induced singular arcs. The fuel-efficiency of orbit raising by periodic Hohmann transfers was of the same order-of magnitude as that an FKT thus demonstrating at least two possibilities: (i) the propellant consumed by an FKT is close to the optimal if a periodic Hohmann maneuver is also close to the optimal, or (ii) since the propellant consumed by a Hohmann-type maneuver is close to the non-optimal FKT, the periodic optimal maneuver is quite different from the Hohmann maneuver possibly consisting of singular subarcs.

PUBLICATION:

Ross, I.M. and Alfriend, K.T., "Low-Earth-Orbit Maintenance: Reboost Versus Thrust-Drag Cancellation," Journal of Guidance, Control and Dynamics, Vol. 18, No.4, pp.930–932, July–August 1995.

CONFERENCE PRESENTATION:

Nicholson, J.C. and Ross, I.M., "Performance of Optimal Synergetic Maneuvers," AAS/AIAA Spaceflight Mechanics Meeting, AAS Paper No. 95-120, Albuquerque, NM, 13-16 February 1995.

DOD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Singular arcs, low-earth-orbit maintenance, trajectory optimization

AIR DEFENSE SYSTEM INTEGRATOR (ADSI) AND MULTI-SOURCE TACTICAL SYSTEM (MSTS) SYSTEMS ANALYSIS

I. Michael Ross, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Space Command

OBJECTIVE: This three-year project was aimed at analyzing the Air Defense System Integrator (ADSI) and the Multi-Source Tactical System (MSTS) in support of the warfighter.

SUMMARY: The project began in FY94, much of the work performed was in understanding these new systems, including travel to the Air Force Space Command (AFSC). In FY95, the direction of the project was altered by the sponsor. Attention was focused on investigating advanced concepts that affect the future design on spacecraft. In addition, preliminary work was performed on simulating orbital perturbations on Earth-crossing asteroids.

THESES DIRECTED:

Parish, M.S., LT, USN, "Optimality of Aeroassisted Orbital Plane Change," Master's Thesis, December 1995.

Knudson, W.E., LCDR, USN, "Orbital Perturbation Analysis of Earth-crossing Asteroids" Engineer's Thesis, December 1995.

DOD KEY TECHNOLOGY AREAS: Space Vehicles, Command, Control and Communications

KEYWORDS: Warfighter, advanced concepts, space applications

NEAR-EARTH-OBJECT INTERCEPTION

I. Michael Ross, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Johns Hopkins University

OBJECTIVE: This proposal is for the purpose of analyzing certain space warfighting problems associated with the threat from near-Earth-objects.

SUMMARY: All of the work done in FY95 was in obtaining this grant. The research part of this proposal will be carried out in CY96 and beyond.

DOD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Asteroids, comets, hazard mitigation

AEROBRAKING

I. Michael Ross, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Falcon Air Force Base

OBJECTIVE: This proposal is for the purpose of analyzing aerobraking maneuvers associated with the design of future spacecraft. These maneuvers will be analyzed for their tactical utility to the military, and the driving design parameters will be determined.

SUMMARY: All of the work done in FY95 was in obtaining this grant. The research part of this proposal will be carried out in CY96 and beyond.

DOD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Synergetic maneuvers, spacelift

SATELLITE OPTIMAL ATTITUDE MANEUVERS

Sandi Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Unfunded

OBJECTIVE: To determine time-optimal attitude maneuvers for various spacecraft using direct collocation and nonlinear programming adapted for use on a parallel platform.

SUMMARY: Progress has been slow; a parallel platform to run a test case has been established using PVM on the ECE computers.

DOD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Time-optimal control, parallel processing

PETITE AMATEUR NAVY SATELLITE (PANSAT) STRUCTURAL ANALYSIS

Sandi Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Unfunded

OBJECTIVE: To perform structural analysis and design of the electrical housing and circuit boards for PANSAT.

SUMMARY: The dimensions, material, and manufacturing of the EPS housing and circuit boards has been specified and analyzed, using both classical anlytical techniques, and I-DEAS finite element analysis. The structures have been analyzed and designed so that they meet both stress, frequency, and buckling requirements for PANSAT. In addition, specific manufacturing and assembly techniques have been specified for these parts.

THESIS DIRECTED:

Tackett, S., "Design and Analysis of EPS Housing and Circuit Boards for PANSAT," Master's Thesis, June 1995.

DOD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Finite element analysis, structural design

STRUCTURAL ANALYSIS OF THE TOPAZ II SPACE NUCLEAR POWER SYSTEM

Sandi Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Unfunded

OBJECTIVE: To analyze the structural dynamics of the Russian built space nuclear power system, TOPAZ II, using finite element analysis, and to provide support and analysis of the shock and vibration tests on the unit performed at Sandia National Labs on 6-9 September 1994.

SUMMARY: Preliminary analysis and measurements were performed during the summer of 1994, prior to the test, to provide insight into the test procedures and critical parts. The Principal Investigator and two graduate students helped prepare the test unit and observed the test. During the winter and spring of 1995, the test data was analyzed and compared with the results from an I-DEAS finite element model of the test unit. The conclusion was that the model and test results matched very well.

THESES DIRECTED:

Campbell, S., "Random Vibration Analysis of the TOPAZ II Space Nuclear Reactor Power System," Master's Thesis, June 1995.

Raney, E., "Vibration Analysis of TOPAZ II," Master's Thesis, June 1995.

DOD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Finite element analysis, space nuclear power, shock and vibration testing

DESIGN AND IMPLEMENTATION OF A GEOLOCATION SOFTWARE WORKBENCH

Sandi Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Hersch Loomis, Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: To design and implement a multipurpose software tool that can be used to process electronic signals in an effort to determine the signal's point of origin.

SUMMARY: A functional workbench was constructed using the MATLAB software environment. Specific emphasis was placed on: determining the formats and I/O for the data files, propagation path error accounting, geolocation algorithm implementation, and graphical user interface design. A Time Difference of Arrival (TDOA) example was run using the workbench.

THESIS DIRECTED:

Jones, G., "Design and Implementation of a Geolocation Software Workbench," Master's Thesis, December 1995.

DOD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: MATLAB, geolocation

ANALYSIS OF REMOTE SENSING DATA IN LITTORAL REGIONS

Sandi Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Chris Olsen, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: To combine existing data and software packages (IDL, ENVI) to produce information not previously available, or to clarify imagery through sensor fusion.

SUMMARY: To assist in evaluating sensors and their capabilities, a multi-platform experiment was conducted. Known as Hamlet's Cove, a Navy program designed by the United States Special Operations Command (USSOCOM) it was designed to study the utilization of remote sensing for littoral warfare, particularly addressing the mine warfare problem. A wide variety of systems were involved in data collection over an island at Eglin Air Force Base, Fl, including national systems, LANDSAT, SPOT, and airborne sensors during the summer of 1994. NPS was involved with ground truth data collection at the site in conjunction with work being done by NRL. The data from the test was analyzed by merging elector-optical and multi-spectral imagery, and performing Principal Component Analysis to reduce the data to an optimum form for possible target detection.

THESIS DIRECTED:

LaPoint, J., (thesis classified), Engineer's Degree, June 1995.

DOD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Remote sensing, littoral regions

1995

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